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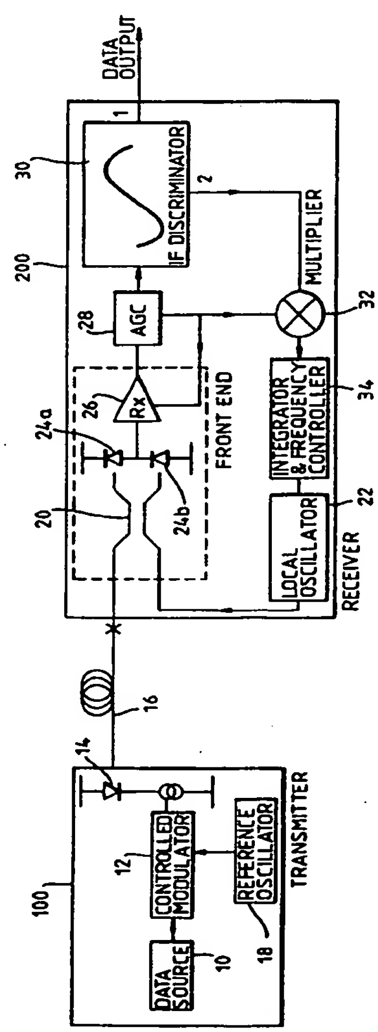
(54) Continuous phase FSK modulated optical transmission system with local osciallator control.

(57) An optical transmission system utilising at a transmitter (100) continuous phase frequency shift keyed modulation of a laser (14) and a coherent heterodyne receiver (200) therefor, the system including at the transmitter means for imposing (18,12) a low frequency modulation on the transmitter optical power and frequency deviation and at the receiver means for extracting (28) from the receiver AGC control signal a replica of the low frequency modulation, means for demodulating (32) the modulated frequency deviation of the received optical signal synchronously with respect to the extracted low frequency signal, means for deriving (34) from the demodulated signal an error signal and a control system responsive to the error signal to control the receiver local oscillator (22) frequency.

Fig.1.



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This invention relat s to an optical transmission system and to receiver tracking arrangements therefor.

A common form of modulation used in optical transmission systems is that known as frequency shift keying (FSK) in which data modulation is impressed as a small frequency shift at the laser output. The resulting frequency modulated optical signal is then passed through an optical discriminator, i.e. an optical filter, to convert the frequency modulated optical signal to an intensity modulated (IM) optical signal. This kind of modulation conversion is described for instance, in British patent specification 2 107 147A.

The FSK is converted to IM by arranging for the frequency spectrum of the optical filter characteristic of the optical discriminator to be matched with the FSK output frequencies so that these frequencies are transmitted by the discriminator with widely different optical attenuations. Particularly in the case of injection lasers, the unregulated output frequency is liable to drift with time so that, in a matter of perhaps only a few minutes, the frequency has drifted by amounts as large as the frequency difference of the FSK. In these circumstances steps need to be taken either to stabilise the optical output of the injection laser against frequency drifts of this magnitude, or some form of feedback control loop is required to provide active matching of the FSK output with the spectral characteristic of the discriminator.

One method for deriving feedback signal for regulating the FSK output frequencies of a transmitter injection laser to match the spectral characteristic of a discriminator taking the form of a Mach Zehnder interferometer, also in the transmitter, has been described by E.G. Bryant et al in an article entitled 'A 1.2 Gbit/s optical FSK field trial demonstration' (Br Telecom Technol J Vol 8 No 2 pp 18-26, April 1990). This method involves impressing a low frequency modulation upon the centre frequency of the injection laser, and using the resulting modulation of an output of the Mach Zehnder interferometer to provide a feedback control signal which regulates the injection laser bias current. However, this method is not applicable where the FSK signal is transmitted over the system and the conversion to IM takes place only in the receiver.

In "High Performance 140 Mbit/s FSK Coherent System", I Hardcastle et al, Electronics Letters, 30th August 1990, Vol.26 No. 18, pp 1523-1524, there is described a 140 Mbit/s FSK heterodyne coherent transmission system having automatic frequency and polarisation acquisition and tracking. In that system the FSK modulation is transmitted over the system t the receiver and the conversion to IM takes place in th receiver. In that system a feedback arrangement utilises part of the receiver front end electrical signal to provide a control signal for a local scillator laser the optical output of which is heterodyne with the incoming FSK to d modulate the optical signal to IF. Such a syst m, how ver, requires i the receiver architecture a s parate local scillator tracking filter.

The present invention utilises the characteristics of a form of FSK modulation known as continuous phase FSK (CPFSK) modulation.

According to the present invention there is provided an optical transmission system utilising at a transmitter continuous phase frequency shift keyed modulation of a laser and a coherent heterodyne receiver therefor, the system including at the transmitter means for imposing a low frequency modulation on the transmitter optical power and frequency deviation and at the receiver means for extracting from the receiver AGC control signal a replica of the low frequency modulation, means for demodulating the modulated frequency deviation of the received optical signal synchronously with respect to the extracted low frequency signal, means for deriving from the demodulated signal an error signal and a control system responsive to the error signal to control the receiver local oscillator frequency.

An embodiment of the invention will now be described with reference to the accompanying drawings, in which:-

Figure 1 is a system block diagram of a CPFSK system,

Figure 2 illustrates a laser modulation characteristic, and

Figure 3 illustrates an intermediate frequency discriminator characteristic.

In the system illustrated in Figure 1 a digital data source 10 in transmitter 100 feeds a data signal to a controlled modulator 12 which controls the drive current for a laser 14. The optical output of the laser is transmitted via optical fibre 16 to receiver 200. The transmitter also includes a reference oscillator 18 which provides a low frequency signal of less than 100 KHz, e.g. 10-20 KHz, which is applied to the modulator 12 to impose a varying modulation depth on both the optical power and optical frequency of the laser output. For example, if the laser drive current modulator 12 causes the laser drive current to have a fixed value for binary data 'O' then the current for binary data '1' is varied by a small amount at the low frequency. This is illustrated in Fig. 2 which shows a plot of optical power and frequency against drive current.

In the receiver 200 the incoming optical signal is mixed in optical coupl r 20 with the optical output of a local oscillator laser 22. The coupl r output feeds balanced photod tectors 24a, 24b and the resulting electrical signal is fed t receiver amplifier 26. The amplifier output is passed through an AGC circuit 28 to IF discriminator 30 to form the data output. The AGC circuit 28 produces a feedback signal to control the gain of amplifier 26. The AGC feedback signal is

also applied to a multiplier 32 together with the baseband output from the IF discriminator. The multiplier eff ctively demodulates the variation imposed on the data '1' content of th optical signal as shown in Fig. 3. The resulting output of the multiplier in effect forms an error signal which is proportional to the error between the data '1' IF frequency and the IF discriminator characteristic. This error signal feeds an integrator-based control circuit 34 which determines the frequency of the local oscillator laser 22. The receiver thus automatically aligns the IF frequencies to the characteristics of the demodulating frequency discriminator, reducing any frequency error between the nominal IF frequency and the frequency discriminator characteristic. The arrangement suppresses the frequency error which would otherwise exist due to any temperature or time induced discrepancy between the characteristics of the demodulating frequency discriminator and the IF tracking filter which would normally be found in an FSK system.

Claims

1. An optical transmission system utilising at a transmitter (100) continuous phase frequency shift keyed modulation of a laser (14) and a coherent heterodyne receiver (200) therefor, the system including at the transmitter means for imposing (18,12) a low frequency modulation on the transmitter optical power and frequency deviation characterised in that the receiver includes means for extracting (28) from the receiver AGC control signal a replica of the low frequency modulation, means for demodulating (32) the modulated frequency deviation of the received optical signal synchronously with respect to the extracted low frequency signal, means for deriving (34) from the demodulated signal an error signal and a control system responsive to the error signal to control the receiver local oscillator (22) frequency.

2. An optical transmission system according to claim 1, characterised in that the means for demodulating the modulated frequency deviation comprises means for multiplying the modulated frequency deviation with the replica of the local oscillator frequency modulation.

3. An optical transmission system according to claim 1, characterised in that means for imposing a low frequency modulation on the transmitter optical frequency deviation comprises a reference oscillator the output of which is applied to caus further modulation of the transmitter laser drive current during data modulation of the laser drive current for one significance only of a binary data input.

4. A method of controlling local oscillator frequency in a receiver for a continuous phas frequency shift k yed modulation optical transmission syst m including the steps of sup rimposing at the system transmitter a low frequency reference modulation on the transmitter optical power and optical frequency and in the receiver demodulating the low frequency deviation variation synchronously with respect to the reference modulation to form an error signal for controlling the receiver local oscillator frequency.

5. A method according to claim 4 wherein the reference frequency is less than 100KHz.

Fig.1.

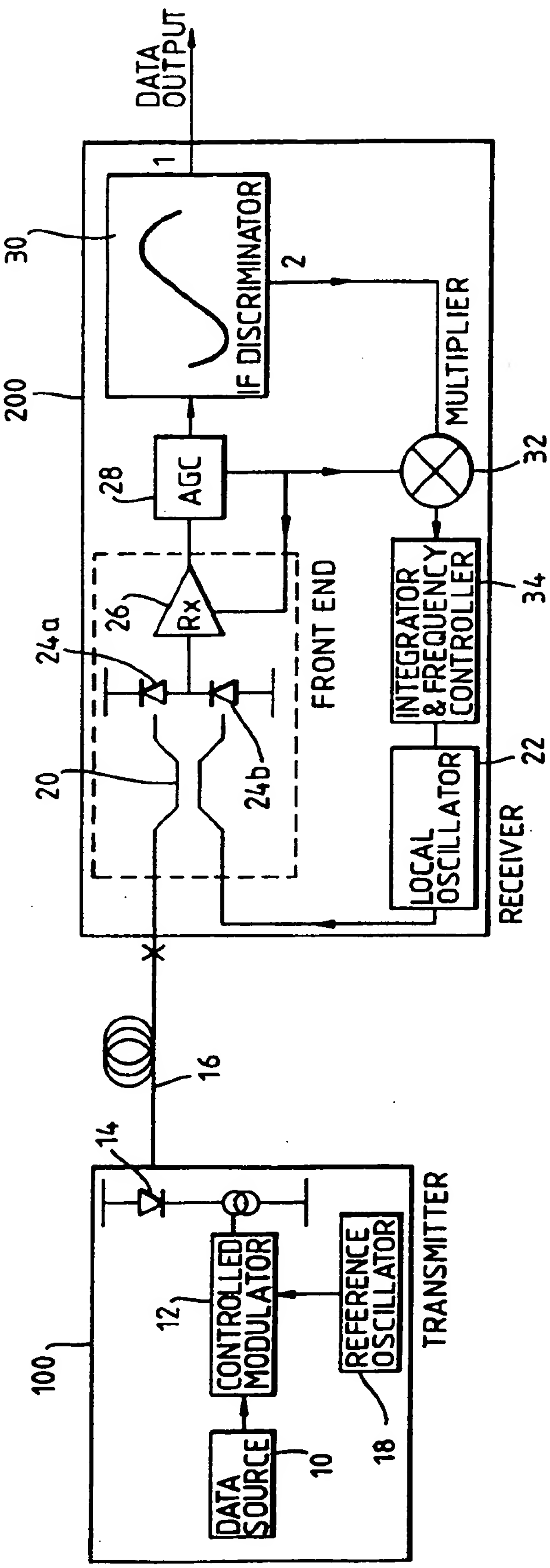

DATA OUTPUT
1
2
IF DISCRIMINATOR
30
200
AGC
28
MULTIPLIER
32
26
Rx
24a
FRONT END
INTEGRATOR & FREQUENCY CONTROLLER
34
20
24b
LOCAL OSCILLATOR
22
RECEIVER
16
14
100
CONTROLLED MODULATOR
12
DATA SOURCE
10
REFERENCE OSCILLATOR
18
TRANSMITTER

Fig. 2.

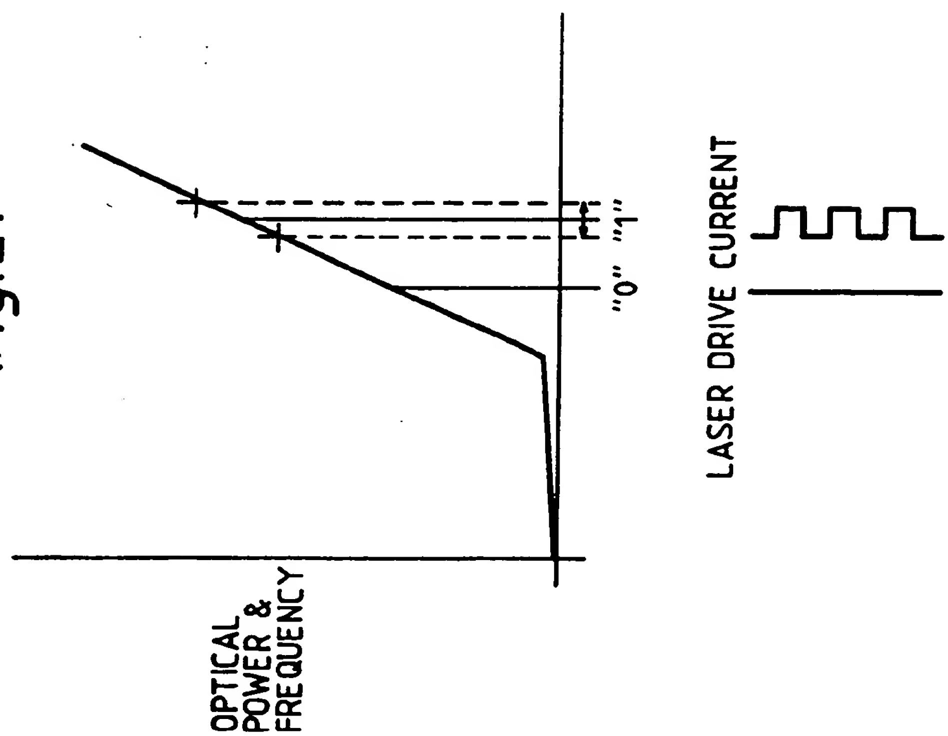
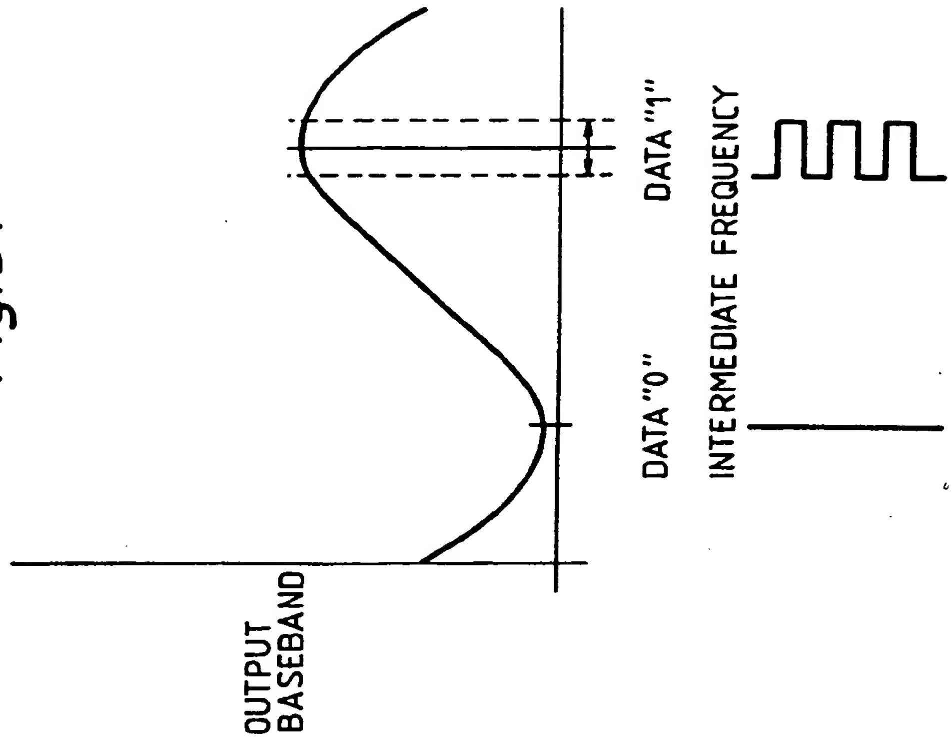

OPTICAL
POWER &
FREQUENCY
"0"
"1"
LASER DRIVE CURRENT

Fig. 3.


OUTPUT
BASEBAND
DATA "0"
DATA "1"
INTERMEDIATE FREQUENCY

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 93300825.2

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP - A2 - 0 142 427 (THOMSON-CSF) * Abstract; claims 1,5 * --	1-4	H 04 B 10/02
A	EP - A2 - 0 247 738 (AT+T) * Abstract; claims * --	1-4	
A	EP - A2 - 0 401 557 (SIEMENS) * Abstract; claim 8 * --	1	
A	EP - A1 - 0 298 484 (SIEMENS) ----		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

H 04 B 9/00
H 04 B 10/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	27-06-1993	BLASL

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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